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A STUDY OF THE POLLEN GRAINS OF INDIAN *CLEMATIS* LINN. (RANUNCULACEAE)

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ABSTRACT

An illustrated account of the pollen grains of 32 species of genus *Clematis* (Dill. ex) Linn., mostly Indian, has been presented and their systematic significance evaluated. The pollen is usually 3-zono-colpate, but some have 4-zono-colpate pollen as well. In *C. cadmia* Buch.-Ham. ex Hk.f. & Thoms., the pollen is panporate. The pollen features in *Clematis* exhibit a predominantly negatively reticulate sexine pattern and are of little phylogenetic significance.

INTRODUCTION

The present investigation has been undertaken to evaluate systematic significance of pollen features in Indian *Clematis* Linn. Some other *Clematis* species have also been included in the study for having bearing on taxonomy or phytogeography of Indian taxa (Kapoor, 1962, 1966, 1983, 1987).

The pollen morphological studies of the family Ranunculaceae date back, according to Wodehouse (1935), to an English artist F. Bauer who between 1790-1840 sketched the pollen of a number of species including *Anemone hortensis* and *Caltha palustris*. However, the detailed account on its pollen morphology was published much later by Wodehouse in 1936. He described the pollen of *Clematis* as 3-colpate. Kumazava (1937) put forth an illustrated account of pollen morphology of the Ranunculaceae including *Clematis*. Erdtman (1952) reported rugate pollen grains in *Clematis viorna* and forate in *C. patens*, besides the 3-colpate ones. Ikuse (1956) investigated pollen morphology of Japanese Ranunculaceae including 8 species of *Clematis* and reported polyforate grains in *C. stans* and *C. patens* and 3-colporoidate in *C. japonica*. Chaubal and Deodikar (1963) observed 3-colpate and 3-colp(or)ate condition in *C. gouriana* and *C. wightiana* pollen grains respectively, collected from Western Ghats. Erdtman *et al.* (1963) reported 3-colpate pollen in Scandinavian *Clematis*. Vishnu-Mittre and Sharma (1963) observed 3-colpate pollen in several species of Indian *Clematis*. Nair (1965) also studied many *Clematis* species and found 3-colpate pollen except in *C. grata* where the pollen grains are panporate (pores 6 in number).

Ting-su (1949), Bakker (1956), Hyde and Adams (1958), Huang (1970, 1971), Rao and Tian (1976), Petrov & Borisovaivanova (1976) are some of the other workers who have also contributed to the study of *Clematis* pollen.

Taxonomic studies on *Clematis* by Kapoor (1962, 1965, 1966, 1969, 1983) brought to light that Indian taxa have been subjected to merging, splitting or change of status from time to time. In several cases what has been regarded as a species actually represented a complex of distinct entities, each claiming a separate status, specific or infraspecific. In cases of this kind, if no voucher specimen was cited in the earlier study—and this is so in most of the cases—it is now impossible to precisely correlate the available description with the concerned taxon. This has necessi-

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tated investigation of pollen in *Clematis* afresh correlating each description to the source of material.

MATERIAL AND METHOD

The polliniferous material was obtained from the herbarium specimens, and its details are cited in Table 1. The acronyms used for different herbaria are after Stafleu (1981).

The pollen slides, were prepared by acetolysis method as outlined by Erdtman (1952). A part of the unacetolysed pollen material was stained with safranin and mounted in glycerine to compare with the size of acetolysed pollen. The unacetolysed pollen grains were found to be smaller than the acetolysed ones ; however, all measurements were taken on random selection of 40-50 acetolysed pollen grains only per species. The observations were recorded with the help of light microscopy (Olympus microscope with highest magnification of 100 × 15).

DESCRIPTION

Pollen grains : *3-zono-colpate* :

Clematis acuminata DC. subsp. **acuminata** (figs. 65-67)

Prolate (30 × 20 μm) ; colpi long, thin, running from pole to pole, colpi membrane ornamented. Exine 2 μm thick. Sexine as thick as nexine. Sexine tegillate, negatively reticulate.

C. acuminata DC. subsp. **andersonii** (Brühl) Kapoor (figs. 70-71)

Oblate-spheroidal (25 × 30 μm) ; colpi long, thin, running from pole to pole, colpi membrane ornamented. Exine 1.5 μm thick. Sexine as thick as nexine. Sexine tegillate, negatively reticulate.

C. acuminata DC. subsp. **sikkimensis** (Hk. f. et Thoms.) Brühl var. **sikkimensis** (figs. 77-78)

Prolate spheroidal (30 × 28 μm) ; colpi long, thin, running from pole to pole, colpi membrane ornamented. Exine 2 μm thick. Sexine as thick as nexine. Sexine tegillate, negatively reticulate.

C. acutangula Hk. f. et Thoms. (figs. 30-32)

Spheroidal (30 μm in diameter), rarely prolate-spheroidal (30 × 28 μm) ; colpi long, running from pole to pole, colpi membrane ornamented. Exine about 2 μm thick. Sexine as thick as nexine. Sexine tegillate, negatively reticulate.

C. andersonii (Cl. ex Ktze.) Hj. Eichler (figs. 39-40)

Subprolate (28 × 24 μm) ; colpi long, thin, running from pole to pole, colpi membrane ornamented. Exine 2 μm thick. Sexine slightly thicker than nexine. Sexine tegillate, finely negatively reticulate.

C. apiculata Hk. f. et Thoms. (figs. 52-53)

Prolate-spheroidal (26.0 × 25.5 μm) ; colpi long, thin, running from pole to pole, colpi membrane ornamented. Exine 2 μm thick. Sexine as thick as nexine, Sexine tegillate, negatively reticulate.

C. barbellata Edgew. (fig. 16)

Subprolate (30 × 25 μm) ; colpi long, thin, running from pole to pole, colpi membrane ornamented. Exine about 1.5 μm thick. Sexine as thick as nexine. Sexine tegillate, finely negatively reticulate.

C. buchananiana DC. var. **buchananiana** (figs. 68-69)

Subprolate (38 × 32 μm) ; prolate-spheroidal (33.5 × 33.0 μm) or oblate-spheroidal (25.0 × 26.5 μm) ; colpi long, thin, running from pole to pole, colpi membrane ornamented. Exine 2 μm thick. Sexine as thick as nexine. Sexine, tegillate, negatively reticulate.

C. connata DC. (figs. 72-73)

Subprolate (40 × 35 μm) ; colpi long, thin, running from pole to pole, colpi membrane ornamented. Exine 2 μm thick. Sexine as thick as nexine. Sexine tegillate, negatively reticulate.

C. fasiculiflora Franchet (figs. 27-29)

Prolate (30 × 20 μm); subprolate (30 × 22 μm) or prolate-spheroidal (28 × 26 μm) ; colpi long, thin, running from pole to pole, colpi membrane ornamented. Exine 2 μm thick. Sexine thicker than nexine. Sexine tegillate, negatively reticulate.

Clematis fulvicoma Rehd. et Wils. (figs. 22-24)

Prolate-spheroidal (21 × 20 μm); colpi long, thin, running from pole to pole, colpi membrane ornamented. Exine 1.5 μm thick. Sexine as thick as nexine. Sexine tegillate, faintly negatively reticulate.

C. gouriana Roxb. ex DC.

Subprolate (25 × 20 μm); colpi long, thin, running from pole to pole, colpi membrane ornamented. Exine 2 μm thick. Sexine as thick as nexine. Sexine tegillate, negatively reticulate.

C. grata Wall. (figs. 35-36)

Prolate (30 × 22 μm); colpi long, thin, running from pole to pole, colpi membrane ornamented. Exine 2 μm thick. Sexine slightly thicker than nexine. Sexine tegillate, negatively reticulate.

C. graveolens Lindl.

Subprolate (28 × 22 μm); colpi long, thin, running from pole to pole, colpi membrane ornamented. Exine 2 μm thick. Sexine as thick as nexine. Sexine tegillate, negatively reticulate.

C. japonica Thunb. (figs. 6-7)

Prolate (32 × 20 μm); colpi long, thin, running from pole to pole, colpi membrane ornamented. Exine about 2 μm thick. Sexine as thick as nexine. Sexine tegillate, negatively reticulate.

C. kerriana Drumm. et Craib (figs. 43-44)

Prolate-spheroidal (25 × 22μ m); subprolate (30 × 24 μm) or prolate (28 × 20 μm); colpi long, thin, running from pole to pole, colpi membrane ornamented. Exine 2 μm thick. Sexine as thick as nexine. Sexine tegillate, faintly negatively reticulate.

C. meyeniana Walp. (figs. 79-80)

Subprolate (35.0 × 30.5 μm); rarely prolate-spheroidal (30.5 × 30.0 μm); colpi long, thin, running from pole to pole, colpi membrane ornamented. Exine 2 μm thick. Sexine as thick as nexine. Sexine tegillate, negatively reticulate.

C. montana Buch.-Ham. ex DC. subsp. **montana** var. **manipurensis** Brühl (figs. 8-9)

Prolate-spheroidal (29.0 × 28.5 μm); colpi long, thin, running from pole to pole, with acute apices, colpi membrane ornamented. Exine about 2 μm thick. Sexine slightly thicker than nexine. Sexine tegillate, negatively reticulate.

C. munroiana Wight (figs. 19-21)

Subprolate (24 × 20 μm); colpi long, thin, running from pole to pole, colpi membrane ornamented. Exine 1.5 μm thick. Sexine as thick as nexine. Sexine tegillate, faintly negatively reticulate.

C. orientalis Linn. var. **obtusifolia** Hk. f. et Thoms. (figs. 59-60)

Prolate-spheroidal (30.5 × 30.0 μm); colpi long, thin, running from pole to pole, colpi membrane ornamented. Exine 1.5 μm thick. Sexine slightly thicker than nexine. Sexine tegillate, negatively reticulate.

C. puberula Hk. f. et Thoms. (figs. 33-34)

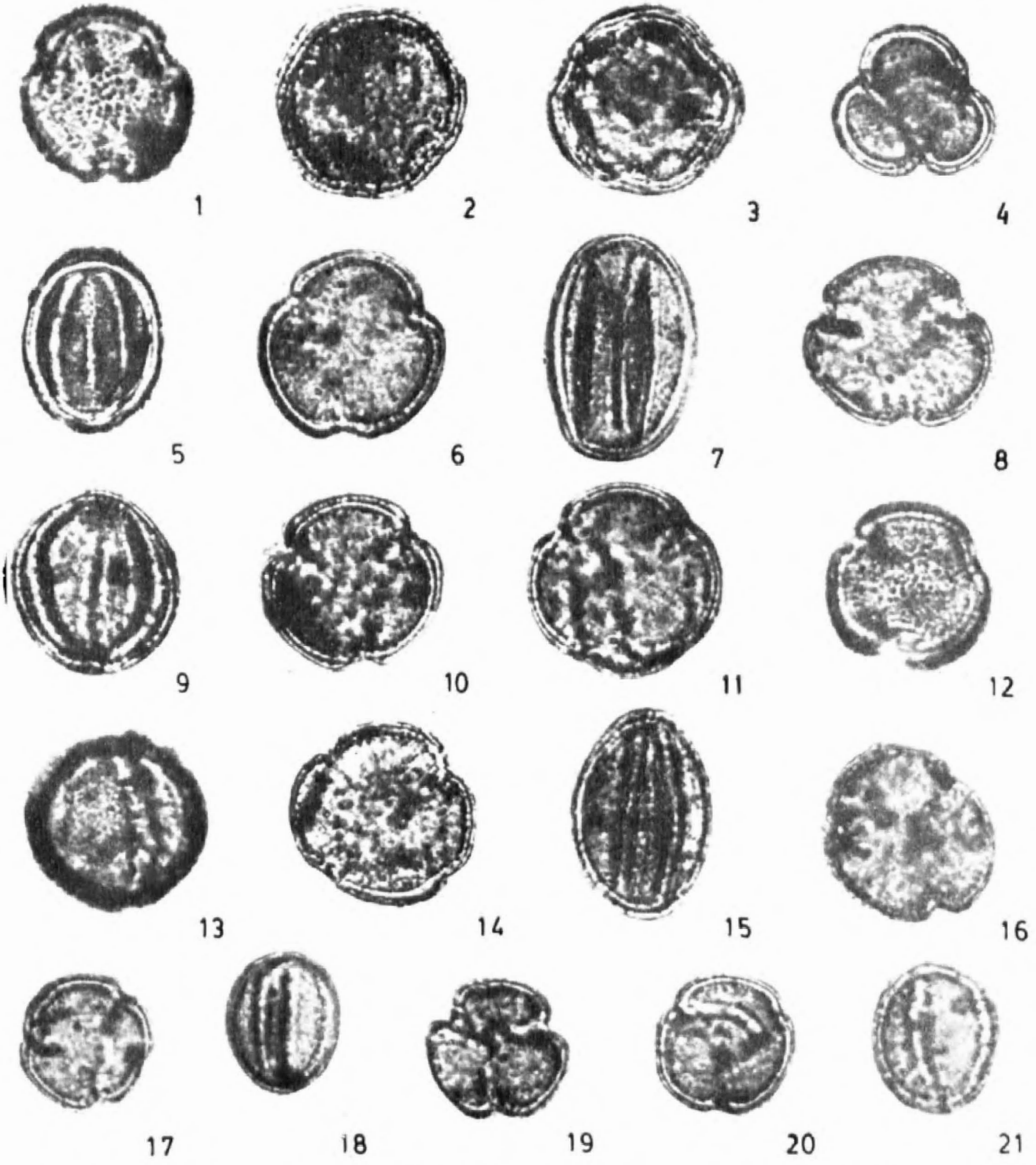
Prolate (28 × 20 μm); colpi long, thin, running from pole to pole, colpi membrane ornamented. Exine 1.5 μm thick. Sexine as thick as nexine. Sexine tegillate, faintly and finely negatively reticulate.

C. roylei Rehd. var. **patens** (Haines) Kapoor

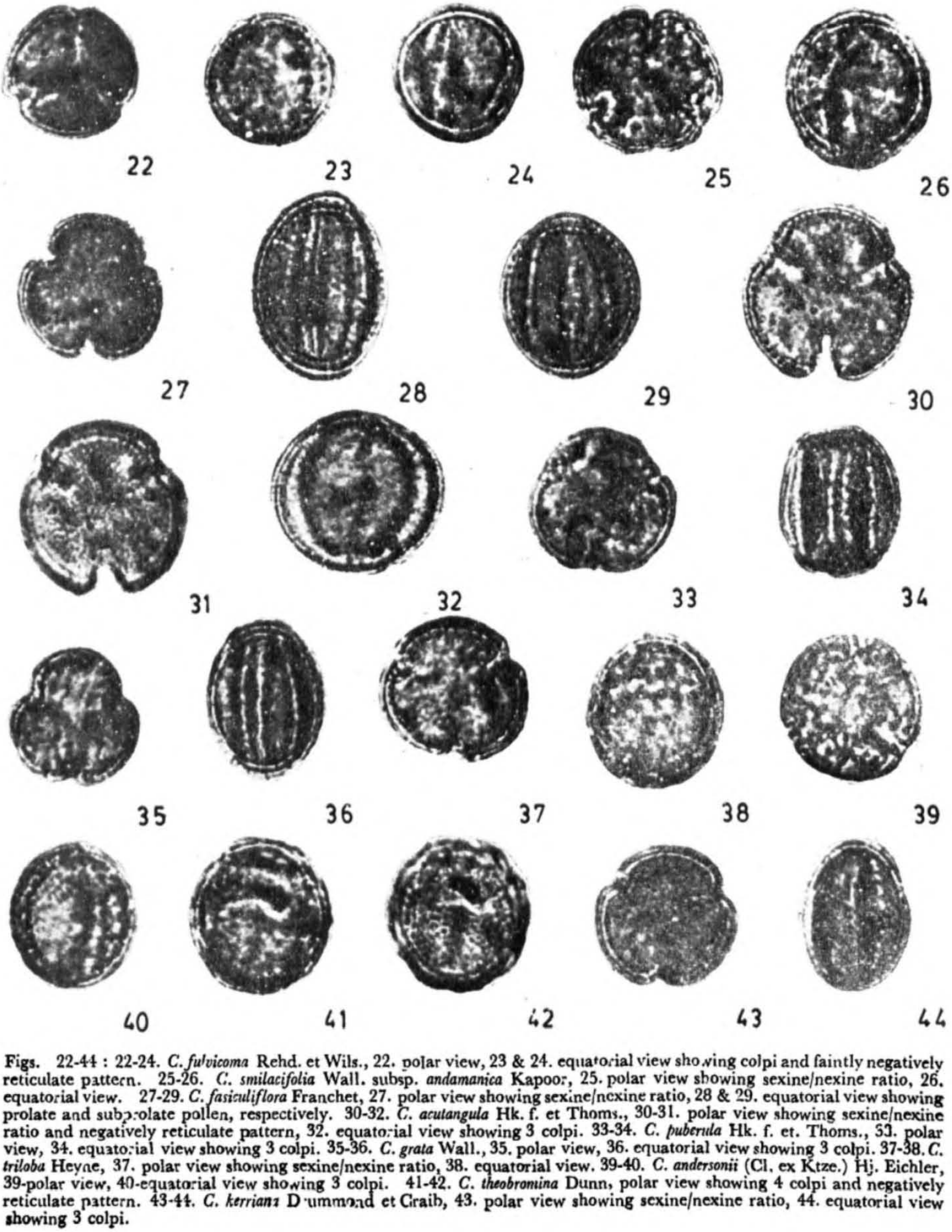
Sub-prolate (38 × 30 μm); colpi long, thin, running from pole to pole, colpi membrane ornamented. Exine 1.5 μm thick. Sexine slightly thinner than nexine. Sexine tegillate, negatively reticulate.

C. roylei Rehd. var. **roylei**

Spheroidal (25.5 × 25.0 μm); colpi long, thin, running from pole to pole, colpi membrane ornamented. Exine 2 μm thick. Sexine as thick as nexine. Sexine tegillate, negatively reticulate.



Figs. 1-21 : 1, 10-13. *Clematis tongluensis* (Bruhl) Tamura var. *tongluensis*, 1 & 12. polar view showing negatively reticulate pattern, 10. polar view showing sexine/nexine ratio, 11. polar view showing 4 colpi, 13. equatorial view showing 3 colpi., 2-3. *C. cadmia* Buch.-Ham. ex Hk. f. et Thoms., Panporate pollen., 4-5. *C. montana* Buch.-Ham. ex DC. subsp. *montana* var. *montana*, 4. polar view showing sexine/nexine ratio, 5. equatorial view showing 3 colpi. 6-7. *C. japonica* Thunb., 6. polar view showing sexine/nexine ratio, 7. equatorial view showing 3 colpi. 8-9. *C. montana* Buch.-Ham. ex DC. subsp. *montana* var. *manipurensis* Brühl, 8. polar view showing sexine/nexine ratio, 9. equatorial view showing 3 colpi. 14-15. *C. montana* Buch.-Ham. ex DC. subsp. *praecox* Ktze. 14-polar view showing 4 colpi ; 15-equatorial view showing 3 colpi. 16. *C. barbellata* Edgew. var. *barbellata*, 3-colpate pollen (polar view). 17-18. *C. smilacifolia* Wall. subsp. *smilacifolia* var. *smilacifolia*, 17. polar view showing sexine/nexine ratio, 18. equatorial view showing 3 colpi and faintly negatively reticulate pattern. 19-21. *C. munroiana* Wight, 19 & 20. polar view showing faintly negatively reticulate pattern and sexine/nexine ratio, 21. equatorial view.



Figs. 22-44 : 22-24. *C. fulvicoma* Rehd. et Wils., 22. polar view, 23 & 24. equatorial view showing colpi and faintly negatively reticulate pattern. 25-26. *C. smilacifolia* Wall. subsp. *andamanica* Kapoor, 25. polar view showing sexine/nexine ratio, 26. equatorial view. 27-29. *C. fasiculiflora* Franchet, 27. polar view showing sexine/nexine ratio, 28 & 29. equatorial view showing prolate and subprolate pollen, respectively. 30-32. *C. acutangula* Hk. f. et Thoms., 30-31. polar view showing sexine/nexine ratio and negatively reticulate pattern, 32. equatorial view showing 3 colpi. 33-34. *C. puberula* Hk. f. et. Thoms., 33. polar view, 34. equatorial view showing 3 colpi. 35-36. *C. grata* Wall., 35. polar view, 36. equatorial view showing 3 colpi. 37-38. *C. triloba* Heyne, 37. polar view showing sexine/nexine ratio, 38. equatorial view. 39-40. *C. andersonii* (Cl. ex Ktze.) Hj. Eichler, 39-polar view, 40-equatorial view showing 3 colpi. 41-42. *C. theobromina* Dunn, polar view showing 4 colpi and negatively reticulate pattern. 43-44. *C. kerriana* Drummond et Craib, 43. polar view showing sexine/nexine ratio, 44. equatorial view showing 3 colpi.

Clematis smilacifolia Wall. subsp. **andamanica** Kapoor (figs. 25-26)

Prolate-spheroidal (28.6 × 26.0 μm) ; colpi long, thin, running from pole to pole, colpi membrane ornamented. Exine 2.5 μm thick. Sexine as thick as nexine and slightly undulated. Sexine tegillate, negatively reticulate.

C. smilacifolia Wall. subsp. **smilacifolia** var. **smilacifolia** (figs. 17-18)

Subprolate (25 × 20 μm) ; colpi long, thin, running from pole to pole, colpi membrane ornamented. Exine 1.5 μm thick. Sexine as thick as nexine. Sexine tegillate, obscure-faintly negatively reticulate.

C. smilacifolia Wall. subsp. **smilacifolia** var. **subpeltata** (Wall.) Ktze.

Subprolate (26 × 20 μm) ; colpi long, thin, running from pole to pole, colpi membrane ornamented. Exine 1.5 μm thick. Sexine as thick as nexine. Sexine tegillate, negatively reticulate.

C. triloba Heyne (figs. 37-38)

Prolate-spheroidal (25.5 × 25.0 μm) or subprolate (25 × 22 μm) ; colpi long, thin, running from pole to pole, colpi membrane ornamented. Exine 2 μm thick. Sexine as thick as nexine. Sexine tegillate, negatively reticulate.

C. wightiana Wall. ex Wight et Arn.

Prolate-spheroidal (30.5 × 30.0 μm) or subprolate (30 × 25 μm) ; colpi long, thin, running from pole to pole, colpi membrane ornamented. Exine 2 μm thick. Sexine as thick as nexine. Exine slightly thicker at the poles. Sexine tegillate, negatively reticulate.

Pollen grains commonly 3-zono-colpate, rarely 4-zono-colpate :

C. acuminata DC. subsp. **sikkimensis** (Hk. f. et Thoms.) Brühl var. **clarkei** (Ktze.) Brühl (figs. 74-76)

Subprolate (32 × 28 μm) ; colpi long, thin, running from pole to pole, colpi membrane ornamented. Exine 2 μm thick. Sexine as thick as nexine. Sexine tegillate, negatively reticulate.

C. apiifolia DC. (fig. 81)

Prolate-spheroidal (28.0 × 26.5 μm) ; colpi long, thin, running from pole to pole, colpi membrane ornamented. Exine 2 μm thick. Sexine as thick as nexine. Sexine tegillate, negatively reticulate.

C. asplenifolia Schrenk (figs. 54-56)

Prolate-spheroidal (20.5 × 20.0 μm) ; colpi long, thin, running from pole to pole, colpi membrane ornamented. Exine 1.5 μm thick. Sexine as thick as nexine. Sexine tegillate, negatively reticulate.

C. glauca Willd. (figs. 63-64)

Prolate-spheroidal (30.5 × 30.0 μm) ; colpi long, running from pole to pole, colpi membrane ornamented. Exine 1.5 μm thick. Sexine as thick as nexine. Sexine tegillate, negatively reticulate.

C. hedysarifolia DC. (figs. 49-51)

Prolate-spheroidal (22 × 21 μm) ; colpi long, thin, running from pole to pole, colpi membrane ornamented. Exine 2 μm thick. Sexine as thick as nexine. Sexine tegillate, negatively reticulate.

C. terniflora DC. (figs. 84-85)

Subprolate (30 × 25 μm) or oblate-spheroidal (26 × 28 μm) ; colpi long, thin, running from pole to pole, colpi membrane ornamented. Exine 2 μm thick. Sexine as thick as nexine. Sexine tegillate, negatively reticulate.

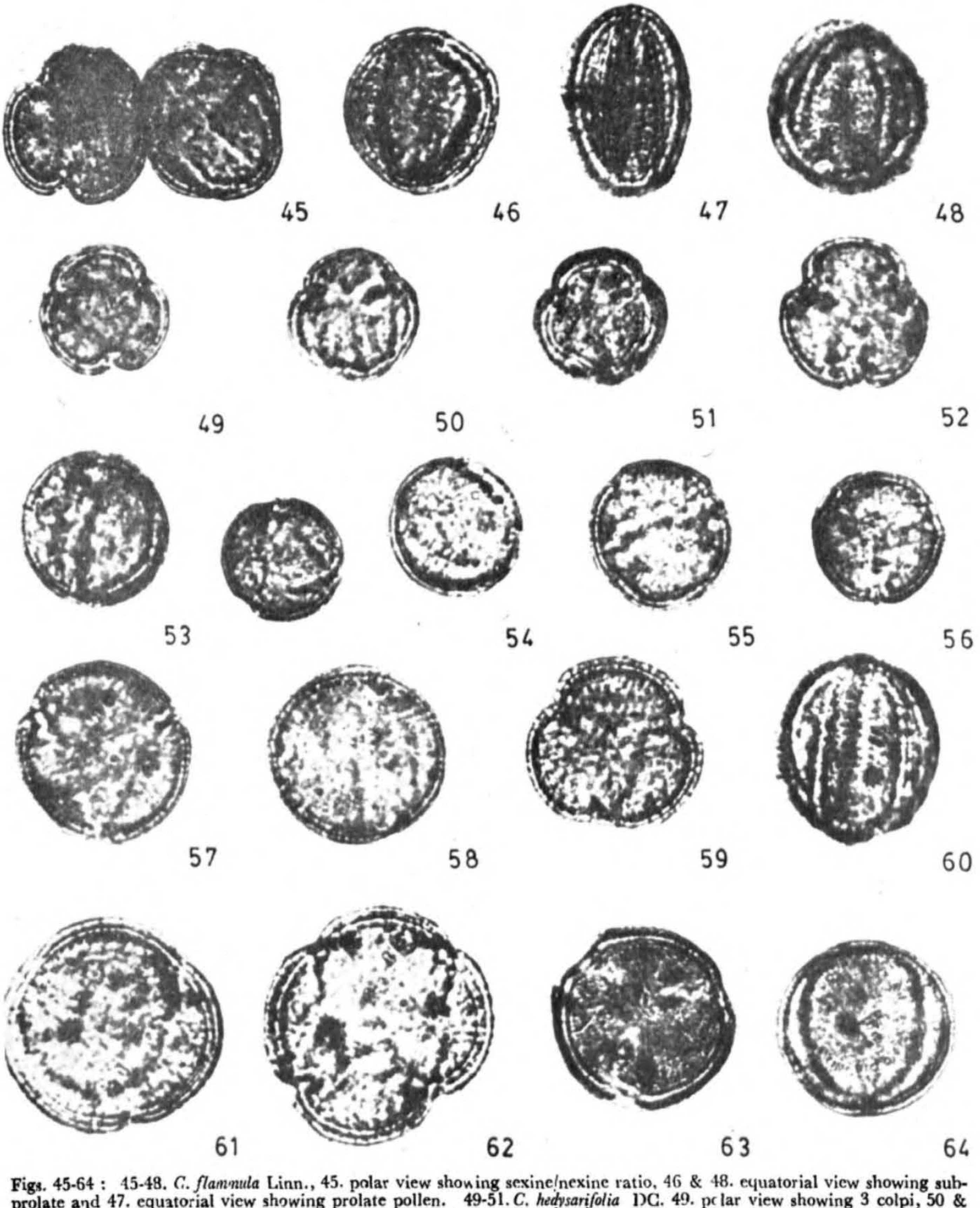
C. tongluensis (Brühl) Tamura (figs. 1, 10-13)

Prolate-spheroidal (30.5 × 30.0 μm) ; colpi long, thin, running from pole to pole, colpi membrane ornamented. Exine about 2 μm thick. Sexine as thick as nexine. Sexine tegillate, negatively reticulate.

Pollen grains 3- and 4-zono-colpate in almost equal proportion :

C. flammula Linn. (figs. 45-48)

Prolate-spheroidal (28.5 × 28.0 μm) or prolate (30 × 20 μm) ; colpi long, thin, running



Figs. 45-64 : 45-48. *C. flammula* Linn., 45. polar view showing sexine/nexine ratio, 46 & 48. equatorial view showing subprolate and 47. equatorial view showing prolate pollen. 49-51. *C. hedysarifolia* DC. 49. polar view showing 3 colpi, 50 & 51. polar view showing 4 colpi. 52-53. *C. apiculata* Hk. f. et Thoms., 52. polar view showing 3 colpi, 53. equatorial view. 54-56. *C. asplenifolia* Schrenk, 54 & 56. polar view showing 3 colpi 55. polar view showing 4 colpi. 57-58. *C. orientalis* Linn. var. *longicaudata* (Ledeb.) Boiss., 57-3-colpate and 58-4-colpate pollen, 61-polar view showing sexine/nexine ratio, 62. polar view showing 4 colpi. 59-60. *C. orientalis* Linn. var. *obtusifolia* Hk., f. et Thoms., 59. polar view showing sexine/nexine ratio, 60. equatorial view showing 3 colpi. 63-64. *C. glauca* Willd. 63. polar view showing negatively reticulate pattern, 64. equatoral view showing 3 colpi.

from pole to pole, colpi membrane ornamented. Exine 2 μm thick. Sexine as thick as nexine. Sexine tegillate, negatively reticulate.

Clematis montana Buch.-Ham. ex DC. subsp. **praecox** Ktze. (figs. 14-15)

Subprolate (25 × 20 μm) or prolate (30 × 22μ m); colpi long, thin, running from pole to pole, colpi membrane ornamented. Exine 2 μm thick. Sexine as thick as nexine. Sexine tegillate, negatively reticulate.

C. theobromina Dunn (figs. 41-42)

Oblate-spheroidal (28 × 30 μm); colpi long, thin (thickness uneven), running from pole to pole, colpi membrane ornamented. Exine 2 μm thick. Sexine slightly thinner than nexine. Sexine tegillate, negatively reticulate.

Pollen grains 4-zono-colpate more common than 3-zono-colpate :

C. orientalis Linn. var. **longicaudata** (Ledeb.) Boiss. (figs. 57-58, 61-62)

Prolate-spheroidal (35.5 × 35.0 μm); colpi long, thin, running from pole to pole, colpi membrane ornamented. Exine 2 μ m thick. Sexine slightly thicker than nexine. Sexine tegillate, negatively reticulate.

Pollen grains Panporate :

C. cadmia Buch.-Ham. ex Hk. f. et Thoms. (figs. 2-3)

Spheroidal (30 μm in diameter); pores *ca* circular, about 2 μm in diameter, membrane psilate, tenuimarginate. Exine 2 μm thick. Sexine as thick as nexine. Sexine tegillate, finely negatively reticulate.

Naravelia zeylanica (Linn.) DC. (figs. 82-83)

Spheroidal (20 μm in diameter); pores circular, about 2 μm in diameter. Exine 1.5 μm thick. Sexine as thick as nexine. Sexine tegillate, negatively reticulate.

DISCUSSION

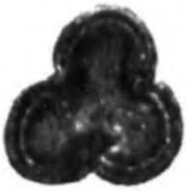
In the present investigation, as could be made out from a perusal of the pollen features, nearly all the species and infraspecific taxa of genus *Clematis* exhibit a more or less similar pattern.

The grains in most of the species are 3-zono-colpate. Interspersed with these, 4-zono-colpate ones have also been observed in a number of taxa. In *C. tongluensis* (Brühl) Tamura, *C. hedysarifolia* DC., *C. asplenifolia* Schrenk, *C. acuminata* DC. subsp. *sikkimensis* Hk. f. et Thoms. var. *clarkei* (Ktze.) Brühl among the Indian species, and in *C. glauca* Willd. (= *C. orientalis* Linn. var. *obtusifolia* Hk. f. et Thoms.), *C. apiifolia* DC. and *C. terniflora* DC. among the exotic species, the 4-zono-colpate ones are rare. In *C. flammula* Linn., another exotic species, and the Indian species *C. montana* Buch.-Ham. ex DC. subsp. *praecox* Ktze. and *C. theobromina* Dunn, both 3-zono-colpate and 4-zono-colpate pollen grains are observed in almost equal proportion. *C. orientalis* Linn. var. *longicaudata* (Ledeb.) Boiss. has 4-zono-colpate grains relatively more abundant.

Incidentally, 4-zono-colpate grains are possibly being recorded in *Clematis* for the first time.

Among the species of *Clematis* investigated here, *C. cadmia* Buch.-Ham. ex Hk. f. et Thoms. is the only one which has panporate pollen grains, differing from all the rest. This species, placed in a separate section *viz.*, Sect. *Viticella*, is characterised by beaked achenes, unlike the ones having long feathery tails, the latter being the most common condition in *Clematis*. Panporate pollen grains have also been found in *Naravelia zeylanica* (Linn.) DC. which was at one time recognised under *Clematis*. These two species are regarded as the most advanced, and may have branched off from the same stock.

The panporate pollen has, nevertheless, been described in species which belong to sections other than *Viticella*, e.g., *C. patens* Morren et Done. (Erdtman, 1952; Ikuse, 1956), *C. stans* Sieb. et Zucc. (Ikuse, 1956), and *C. grata* Wall. (Nair, 1965 p. 10). Incidentally, in the present study only 3-zono-



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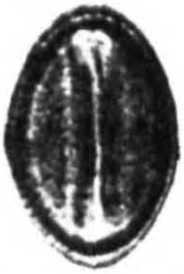

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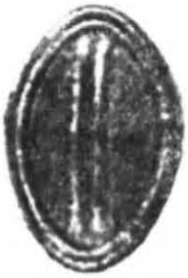

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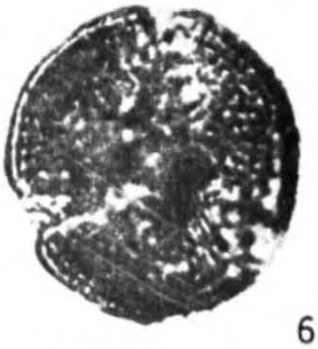

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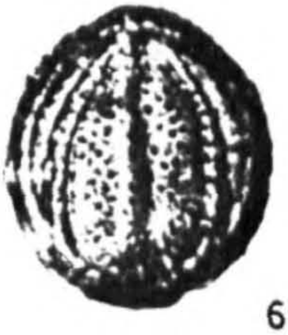

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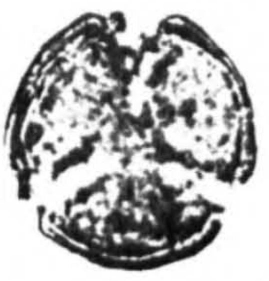

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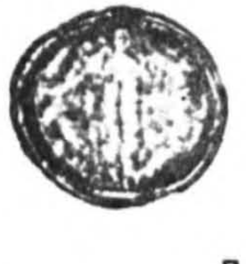

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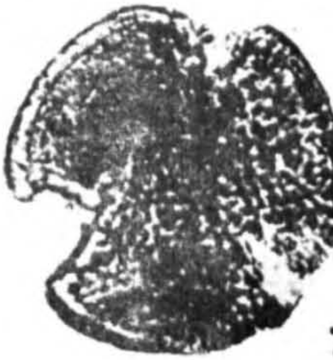

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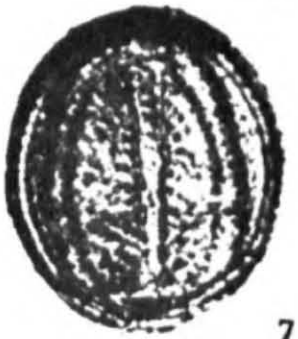

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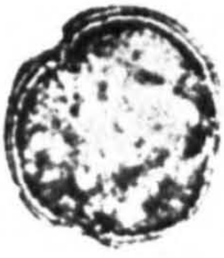

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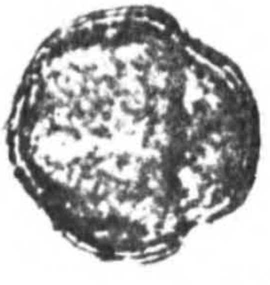

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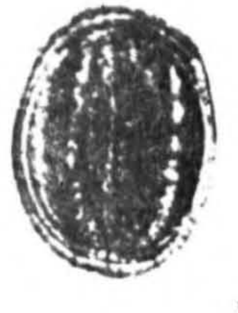

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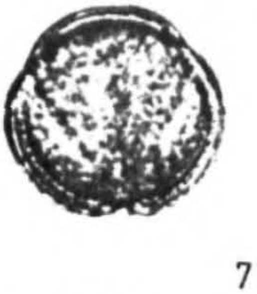

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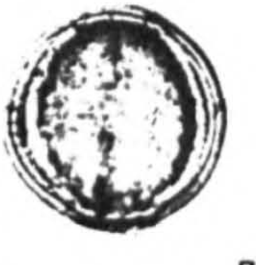

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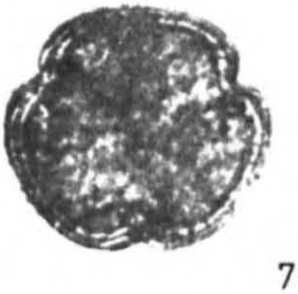

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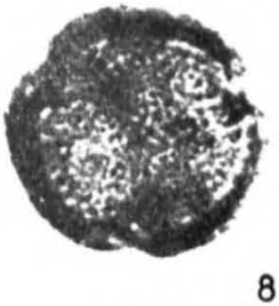

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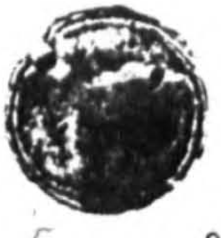

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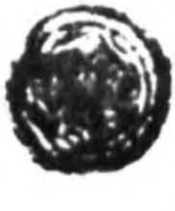

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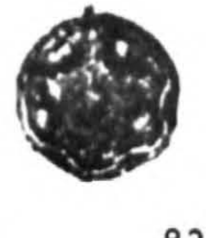

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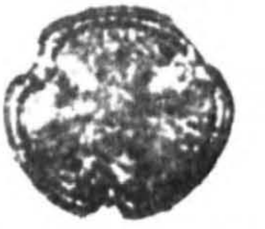

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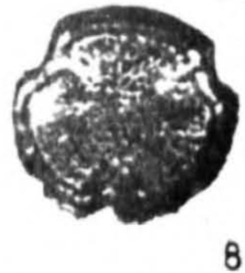

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Figs. 65-85 : 65-67. *C. acuminata* DC. subsp. *acuminata*, 65. polar view showing sexine/nexine ratio, 66 & 67. equatorial view showing negatively reticulate pattern. 68-69. *C. buchananiana* DC. 68. polar view showing sexine/nexine ratio, 69. equatorial view showing negatively reticulate pattern. 70-71 *C. acuminata* DC. subsp. *andersonii* (Bruhl) Kapoor, 70. polar view showing sexine/nexine ratio, 71. equaorial view. 72-73. *C. connata* DC. 72. polar view showing 3-colpi, 73. equatorial view showing negatively reticulate pattern. 74-76. *C. acuminata* DC. subsp. *sikkimensis* (Hk. f. et Thoms.) Brühl var. *clarkei* (Ktze) Brühl, 74. polar view showing 3 colpi, 75. polar view showing 4 colpi, 76. equatorial view showing sexine/nexine ratio. 77-78. *C. acuminata* DC. subsp. *sikkimensis* (Hk. f. et Thoms.) Brühl var. *sikkimensis*, 77. polar view showing sexine/nexine ratio, 78. equatorial view showing 3 colpi. 79-80. *C. meyeniana* Walp. var. *meyeniana*, polar view showing sexine/nexine ratio and negatively reticulate pattern respectively. 81. *C. apiifolia* DC. (polar view). 82-83. *Naravelia zeylanica* (Linn.) DC. panporate pollen. 84-85. *C. terniflora* DC. polar view showing sexine/ nexine ratio and negatively reticulate pattern.

colpate grains are observed in *C. grata* Wall., and not panporate grains as reported by Nair (l.c.).

The porate form has been observed in other genera of Ranunculaceae, though exceptional, in *Coptis, Syndesmon, Thalictrum, Xanthorrhiza apiifolia*—the latter genus regarded as a representative of some ancestral stock, and *Anemone coronaria*—but not in some other *Anemone* species. Wodehouse (1936 p. 498), therefore, concluded that the porate form in the Ranunculaceae appears to have originated 'more than once independently at widely different times' and seems to have at times correlated with anemophily.

Ikuse (1956) reported 3-zono-colporoidate pollen in *C. japonica* Thunb. but in the present investigation only 3-zono-colpate grains are found. However, *C. japonica* Thunb. is regarded to represent a complex composed of distinct entities, and Ikuse (l.c.) might have possibly studied one of these.

The pollen shape, as found in *Clematis* is variable being spheroidal, prolate-spheroidal, oblate-spheroidal, prolate and subprolate. Occasionally prolate, subprolate and prolate-spheroidal grains have all been found in the same species (in *C. kerriana* Drumm. et Craib and *C. fasiculiflora* Franchet). Similarly, *C. buchananiana* DC. has been found to possess subprolate, prolate-spheroidal and oblate-spheroidal grains. The prolate-spheroidal and subprolate forms have, in the same species, been found in *C. wightiana* Wall. ex Wt. et Arn., *C. triloba* Heyne, and *C. meyeniana* Walp. (rarely prolate-spheroidal in the latter). The character of shape obviously cannot be attributed to any dependable systematic significance. In *C. cadmia* Buch.-Ham. ex Hk. f. et Thoms. and *Naravelia zeylanica* (Linn.) DC. only spheroidal pollen grains have been seen. These two get linked up in this feature, as well as, in having panporate pollen grains as mentioned earlier.

The size of the pollen grains is variable from 21-40 μm × 20-35 μm. The largest is that of *C. connata* DC. (40 × 35 μm), followed by that of *C. buchananiana* DC. (38 × 32 μm) and *C. roylei* Rehd. var. *patens* (Haines) Kapoor (38 × 30 μm), all of which belong to sect. Viorna subsect. Connatae ; incidentally, *C. connata* DC. is regarded as one of the most primitive among *Clematis* species. However, other species of this group have smaller pollen grains. *Naravelia zeylanica* (Linn.) DC. is characterised by the smallest grain (20 × 20 μm) and to match with this are those of *C. fulvicoma* Rehd. et Wils. (21 × 20 μm) and *C. hedysarifolia* DC. (22 × 21 μm), the latter two belonging to Sect. *Naraveliopsis*, considered to be one of the advanced groups among *Clematis*.

The colpate pollen grains in *Clematis* are all with colpi long, thin, running from pole to pole and colpi membrane ornamented. In *C. montana* Buch.-Ham. ex DC. subsp. *montana* var. *manipurensis* Brühl colpi are with acute apices, whereas in *C. montana* subsp. *praecox* Ktze. the apices are like any other species. In *C. theobromina* Dunn colpi are thin but of uneven thickness. Exine thickness varies from 1.5-2.5 μm. Sexine is, as a rule, as thick as nexine and tegillate. In *C. fasiculiflora* Franchet sexine is noticeably thicker than nexine ; in *C. montana* Buch.-Ham. ex DC. subsp. *montana* var. *manipurensis* Brühl, *C. grata* Wall., *C. andersonii* (Cl. ex Ktze.) Hj. Eichler and *C. orientalis* Linn. var. *longicaudata* (Ledeb.) Boiss., sexine is only slightly thicker than nexine. The other subspecies of *C. montana viz.*, subsp. *praecox* Ktze. has, however, sexine as thick as nexine. Contrarily in *C. roylei* Rehd. var. *patens* (Haines) Kapoor and *C. theobromina* Dunn, sexine is slightly thinner than nexine. Again in *C. roylei* var. *roylei* and all those taxa related to *C. theobromina* [such as *C. smilacifolia* Wall., *C. andersonii* (Cl. ex Ktze.) Hj. Eichler, *C. fulvicoma* Rehd. et Wils. and *C. munroiana* Wt.] sexine is as thick as nexine. In *C. graveolens* Lindl. exine is slightly thicker at the poles and in

Table 1 : Provenance of the polliniferous material collected from different herbaria

Name of Taxon	*Source of material with details*
1. *Clematis connata* DC.	Simla, 1831, *Lady Dalhousie, s. n.* acc. no. 62628, MH.
2. *C. acuminata* DC. subsp. *acuminata*	*Gamble* 27451, acc. no. 454, CAL.
3. *C. acuminata* DC. subsp. *sikkimensis* (Hk. f. et Thoms.) Brühl var. *sikkimensis*	Tukdah, Distt., 1900 m, 2.12.1876, Gamble 2039A, acc. no. 62624, MH.
4. *C. acuminata* DC. subsp. *sikkimensis* (Hk. f. et Thoms.) Brühl var. *clarkei* (Ktze.) Brühl	*Burkill* 36172, acc. no. 447, CAL.
5. *C. acuminata* DC. subsp. *andersonii* (Brühl) Kapoor	*Anderson* 1811, acc. no. 470. CAL.
6. *C. roylei* Rehd. var. *roylei*	Massoorie, Rajpur, 10.12.1956, *G. S. Puri* 10151, acc. no. 30975, BSI.
7. *C. roylei* Rehd. *var. patens* (Haines) Kapoor	Sundi Buru, Singhbum, 750m, 27.11.1902, *H. H. Haines, s. n.*, acc. no. 86707, MH.
8. *C. buchananiana* DC. ('buchaniana')	'Khasia', 1200-1800 m, *JDH* & *TT, s. n.*, acc. no. 62636, MH ; Mussoorie, 17.12.1966, *S. D. Mahajan* 10779, BSI.
9. *C. orientalis* Linn. var. *longicaudata* (Ledeb.) Boiss.	Tibet, 3000-4000 m, *T. Thomson s. n.*, acc. no. 62615, MH.
10. *C. orientalis* Linn. var. *obtusifolia* Hk. f. & Thoms.	Chamba, *J. H. Lace* 530, acc. no. 58, BSIS.
11. *C. glauca* Willd.	Lippa, Bashahar, 17. 8. 1890, *J. H. Lace* ? 530, acc. no. 392, CAL.
12. *C. graveolens* Lindl.	Sides of the raviens, Mashobra, Hazara, 29.9.1888, *J. F. Duthie* 7423, acc. no. 1471, BSI.
13. *C. wightiana* Wall. ex Wight & Arn.	Nilgiri, 1860, *H. F. C. Cleghorn, s. n.*, acc. no. 58, MH.
14. *C. acutangula* Hk. f. et Thoms.	Rupa and surroundings, 30.9.1964, *J. Joseph* 40385, ASSAM.
15. *C. japonica* Thunb.	Honshu, Kyoto, Japan, 5.6.1972, *Aya Nitta* 13751, LWG.
16. *C. barbellata* Edgew.	Deoban, 2400 m, 30.5. 1893 ; *Chas A. Webb* 2, acc. no. 17, BSIS.
17. *C. montana* Buch.-Ham. ex DC. ssp. *montana* var. *montana*	Simla, May 1917, *H. G. Carter* 307, BSIS.
18. *C. montana* Buch.-Ham. ex DC. subsp. *montana* var. *manipurensis* Brühl.	Arunachal Pradesh ('NEFA'). Senge Dzong, 3050 m 21.5.1957, *R. S. Rao* 7651, ASSAM.
19. *C. montana* Buch.-Ham. ex DC. subsp. *praecox* Ktze.	On way to Phalut, Distt. Darjeeling, 29.5.1962, *S. P. Bhatnagar* 73614, LWG.
20. *C. fasiculiflora* Franchet	Yunnan, China, *George Forest* 471, CAL.
21. *C. tongluensis* (Brühl) Tamura	Tonglu, Darjeeling, 3000 m, July, 1881, *Gamble* 9442, acc. no. 62601, MH.
22. *C. flammula* Linn.	National Botanic Gardens, Lucknow (cultivated), 6.6.1957, *A. L. Gupta* 7313, LWG.
23. *C. terniflora* DC.	Honshu, Kyoto pref., Kyoto, Kibune, Japan, 9.9.1978, *Kana Nagai, s. n.*, acc. no. 68430, LWG.
24. *C. triloba* Heyne	*G. B. Patwardhan, s. n.*, acc. no. 5280, BSI.
25. *C. puberula* Hk. f. & Thoms.	*Clarke* 40560 B, acc. no. 329, CAL.
26. *C. grata* Wall.	Simla, 20.4.1831, *Lady Dalhousie, s.n.*, acc. no. 62610, MH.
27. *C. gouriana* Roxb. ex DC.	Siruvani, Tamil Nadu, 18.12.1960, *A. N. Henry* ANH 948, BLAT ; Coonoor to Burlyar, 30.12.1902, *Barber* 539, acc. no. 31, MH.

Table 1 *contd.*

Name of Taxon	*Source of material with details*
28. *C. kerriana* Drumm. et Craib	*O. Riley* 1887, *acc. no.* 324, CAL.
29. *C. apiculata* Hk.f. & Thoms.	'Khasia', 1200 m, *J. D. H. & T. T., s.n.*, acc. no. 349, CAL.
30. *C. apiifolia* DC.	Honshu, Kyoto pref., Kyoto, Japan 9.9.1978, *Kana Nagai, s.n.*, acc. no. 68434, LWG.
31. *C. meyeniana* Walp. var. *meyeniana*	Isls. Amami ; roadside between Shimokushi and Inokawa, Isl. Tokunoshima, Japan, 28.8.1978, *H. Kata & E. Miki* 353, LWG.
32. *C. asplenifolia* Schrenk	Gilgit, 1855, *G. M. Giles, s. n.*, acc. no. 610, CAL.
33. *C. hedysarifolia* DC.	Londa, Nov. 1891, acc. no. 5255, BSI.
34. *C. smilacifolia* Wall. subsp. *smilacifolia* var. *smilacifolia*.	Kyanskoi, Burma, *I. H. Burkill* 22158, acc. no. 25, BSIS.
35. *C. smilacifolia* Wall. subsp. *smilacifolia* var. *subpeltata* (Wall.) Ktze.	*A. Meebold* 16928, acc. no. 140, CAL.
36. *C. smilacifolia* Wall. subsp. *andamanica* Kapoor	Saddle peak, North Andamans, *N. P. Balakrishnan & N. G. Nair* 4784, PBL.
37. *C. fulvicoma* Rehd. et Wils.	*Lace* 5955, acc. no. 169, CAL.
38. *C. andersonii* (Cl. ex Ktze.) Hj.	Acc. no. 624, CAL.
39. *C. munroiana* Wt.	Akkmalai, Coimbatore Distt. 1595m, 23.1.1962, *J. Josph* 13759 acc. no. 27019, MH.
40. *C. theobromina* Dunn	Korakundha, Nilgiri Dt., Tamil Nadu, 5.1.1971, *B. V. Setty* 37713, MH.
41. *C. cadmia* Buch. -Ham. ex Hk. f. et Thoms.	Katha, Burmah; *I. H. Burkill* 22632, acc. no. 1, BSIS.
42. *Naravelia zeylanica* (Linn.) DC.	Devala-Nadugani Forest, Nilgiri Dt., Tamil Nadu, *E. Vajravelu* 42856, acc. no. 67962, LWG.

C. smilacifolia Wall. subsp. *andamanica* Kapoor, sexine is slightly wavy. Sexine pattern is negatively reticulate, faintly so in *C. fulvicoma* Rehd. et Wils., *C. smilacifolia* Wall. subsp. *smilacifolia* var. *smilacifolia, C. munroiana* Wt. (all belonging to Sect. *Naraveliopsis* and constituent taxa of *C. smilacifolia* complex), and *C. puberula* Hk. f. et Thoms.; it is finely negatively reticulate in *C. cadmia* Buch.-Ham. ex Hk. f. et Thoms.

It is obvious that the above variations exhibit a reticulate pattern with little correlation to gross morphological features; yet these may be utilised in some cases, for taxonomic purpose, in combination with other characters. Since closely related species may have extreme differences and the distant ones similar features, these are of little phylogenetic significance.

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*Not seen in original